On The Coexistence of Density Wave and Superconductivity in $(TMTSF)_2PF_6$

A. Narayanan, P. Chaikin (New York University), A. Kiswandhi, D. Graf, J. S. Brooks (NHMFL, FSU)

Introduction

$(TMTSF)_2PF_6$ shows coexistence of spin density wave (SDW) and superconducting (SC) orders for a small range of pressures. Such coexistence arises also in heavy fermion compounds and pnictides. In $(TMTSF)_2PF_6$ suggestions regarding the coexistence phase include: the creation of metallic soliton walls in the SDW, the microscopic coexistence of both orders in a homogenous phase, and phase separation [1]. The work done at NHMFL provided evidence for phase separation.

Experimental

We used cell 12 (300 mK and 35 Tesla fields) to study magnetoresistance along all three crystal axes. Crystals were grown at NYU, and then 3 pieces of the same crystal were pressurized and measured together.

Results and Discussion

Figure 1a shows the phase diagram and domain distribution measured by resistance anisotropy (NYU and NHMFL) and thermopower anisotropy (NYU) with details match the results of [2]. This is inconsistent with a homogenous coexistence. **Figure 2** shows the existence of magnetoresistance oscillations. Despite its quasi-one dimensional character, the high pressure metal phase of these salts has a Fermi surface lending itself to transitions with SdH like spacing, due to field induced spin density wave (FISDW). The measured oscillations are FISDW as evidenced by their field and temperature dependence. FISDW are not consistent with solitons. Their existence is a fingerprint of the high pressure metal phase and phase separation. However, the frequency of FISDW drops in the coexistence regime, while the SC transition (another signature of the Fermi surface) is unchanged as shown in **Figure 1b**.

Conclusions

The existence of FISDW in the coexistence regime and the constant SC transition temperature suggest phase separation - the metallic domain in coexistence with SDW is essentially the same as in the high pressure metal. However, the change in FISDW frequency suggests a Fermi surface evolving with pressure, how does one reconcile this with the constancy of the transition temperature? The same question has recently risen in heavy fermion SC as well [3]. More experiments at various pressures in this range are planned.

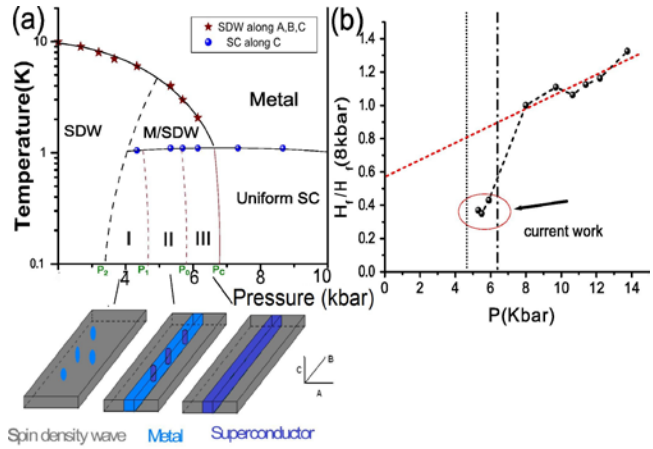

Figure 1 a) Phase diagram and domain evolution from resistance and thermopower, b) Pressure evolution of FISDW frequency.

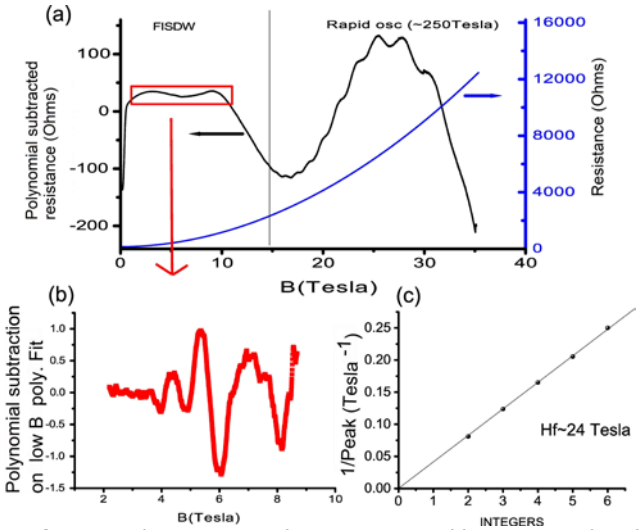

Figure 2 a) Magnetoresistance to 35T, b) FISDW at low fields, c) 1/B dependence of the FISDW.

Acknowledgements

Work at the National High Magnetic Field Laboratory was supported by the NSF Cooperative Agreement No. DMR-0654118, and the state of Florida. Work at NYU was supported by NSF MRSEC award DMR-0820341.

References

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